Calibration over the Mediterranean Area Status of COSMO Model Tests

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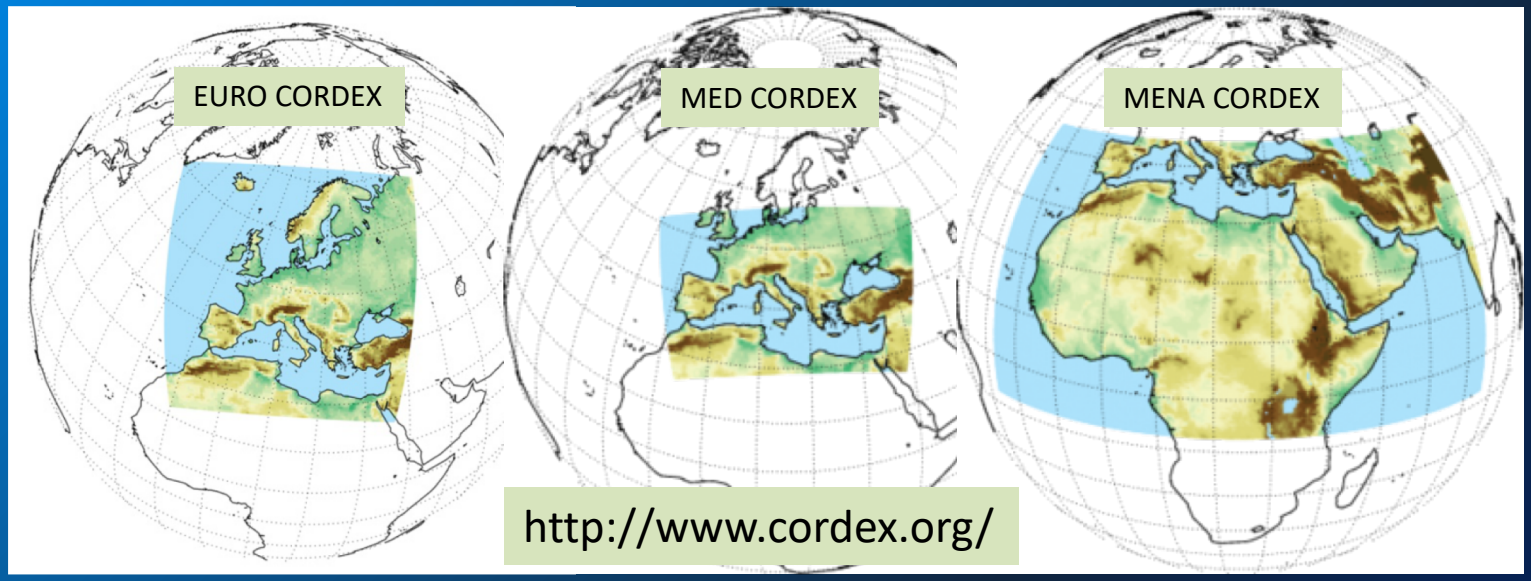
Motivation

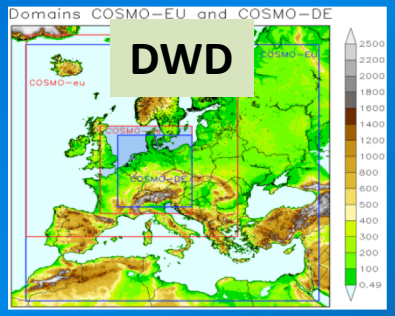
The Mediterranean domain stands, *in perpetuum*, as a formidable challenge for research as well as operational applications in meteorology and climatology.

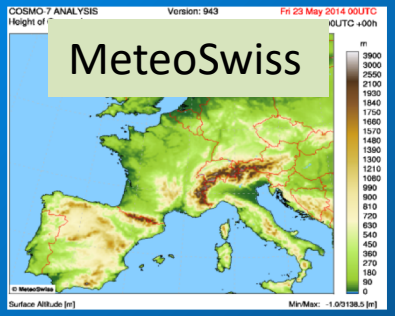
Arguably, this challenge lies in the *evenly distributed* land and sea areas accompanied by exceptional orographic and marine complexities as well as the crucial role of the Mediterranean in *all* tropical, subtropical and mid-latitude regions regarding Europe, Affrica and the Middle-East.

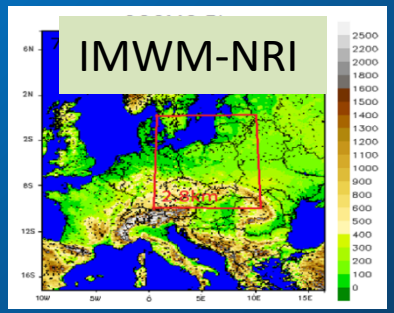


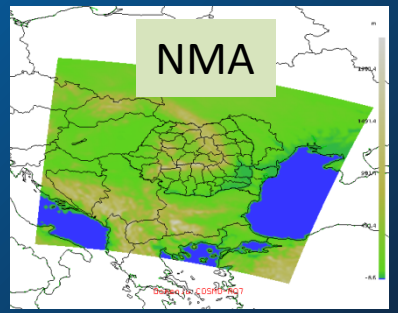
Motivation (cont.)

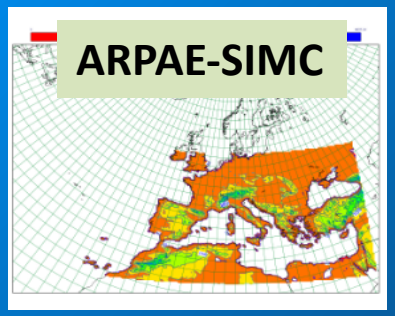
All COSMO Members include the Mediterranean, or part of it, in their operational model runs!!

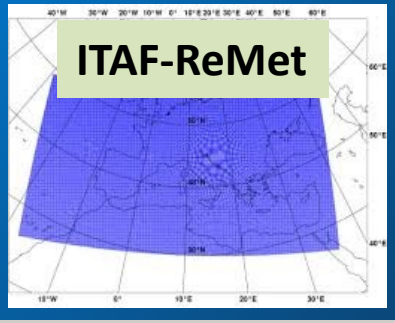


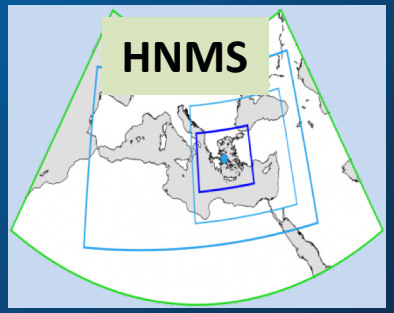


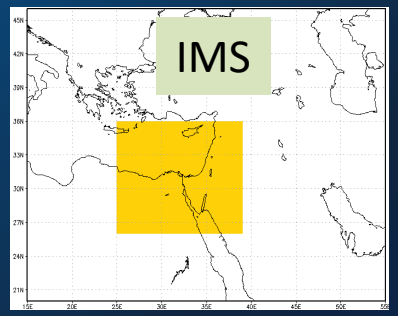


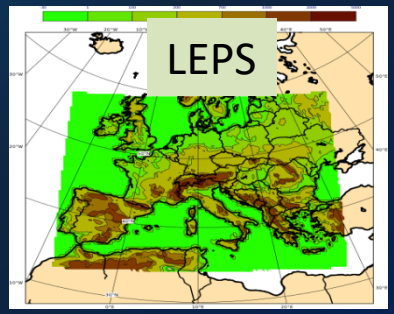








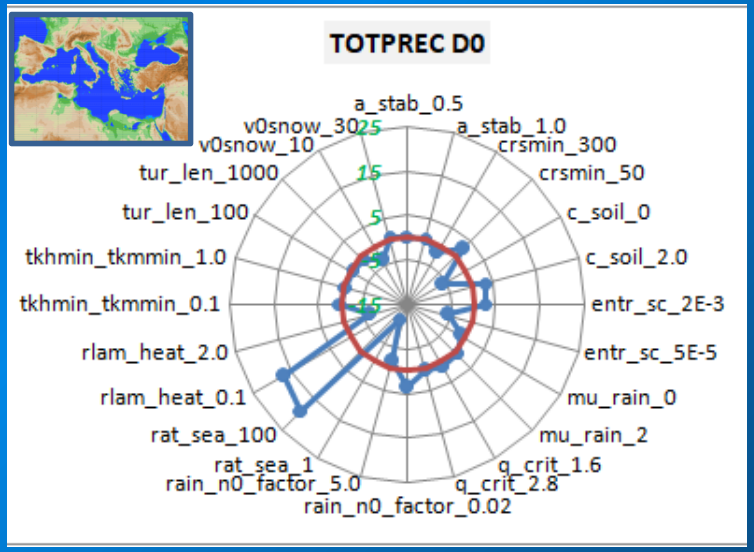




Motivation (cont.)

In sequence to CALMO philosophy , it has been shown that Metiterranean demonstrates strong *sensitivity* for several COSMO parameters.

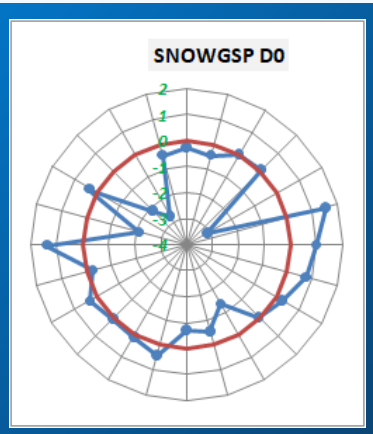
http://www.cosmo-model.org/content/consortium/generalMeetings/general2017/parallel/COSMO-GM2017_parallel_Euripides.pdf
http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport42.pdf

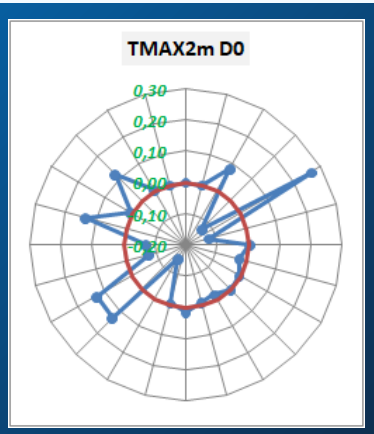


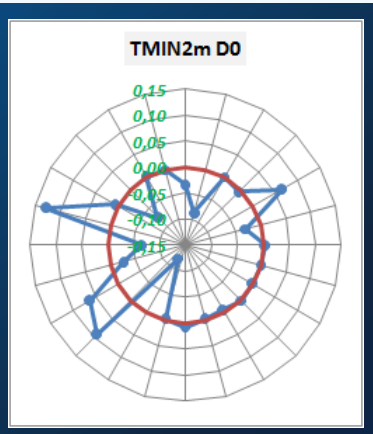
$$S_{<P>}(\%) = \frac{< P >_{TEST} - < P >_{DEFAULT}}{< P >_{DEFAULT}} \bullet 100$$

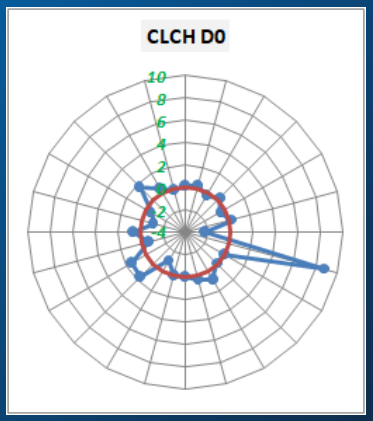
$< P >$ stands for $< SNOWGSP >$ *or* $< TOTPREC >$ *or* $< CLCL >$ *or* $< CLCM >$ *or* $< CLCH >$ *or* $< CLCT >$

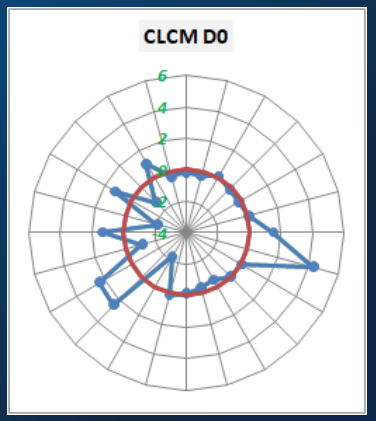
$$S_{\begin{bmatrix} TMIN2m \\ TMAX2m \end{bmatrix}} = \begin{bmatrix} < TMIN2m > \\ < TMAX2m > \end{bmatrix}_{TEST} - \begin{bmatrix} < TMIN2m > \\ < TMAX2m > \end{bmatrix}_{DEFAULT}$$

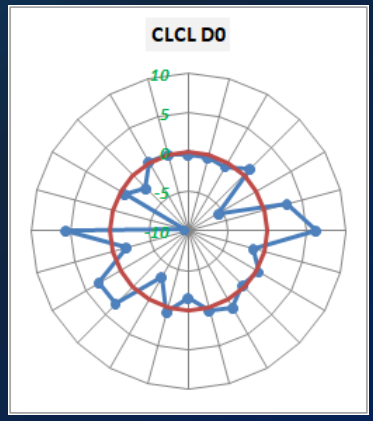










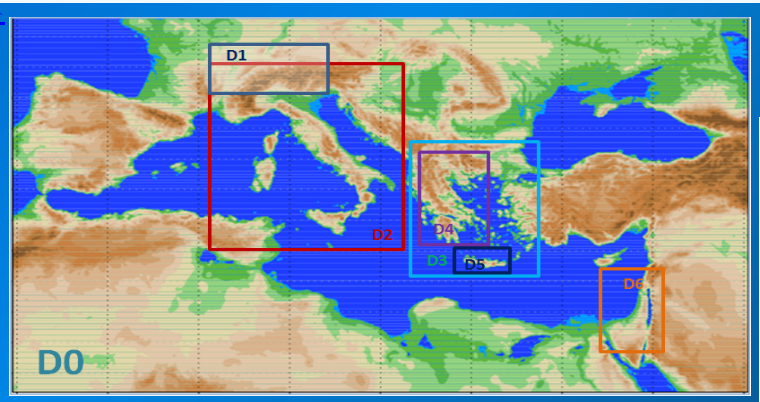


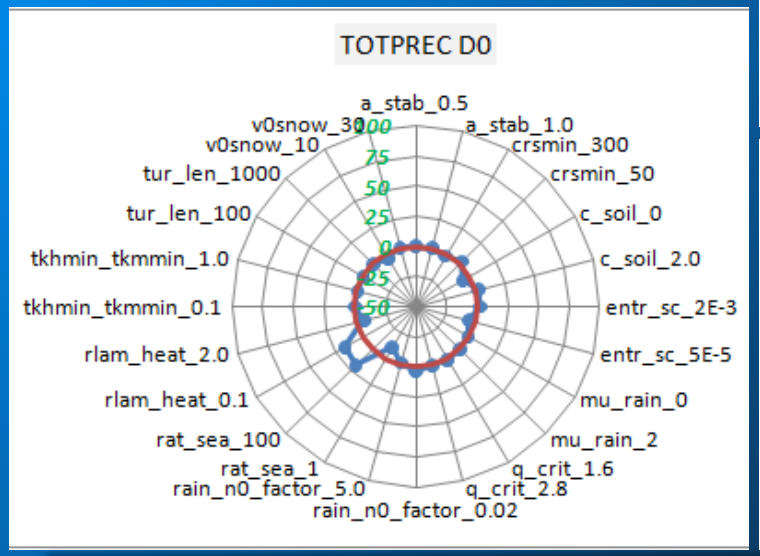
Motivation (cont.)

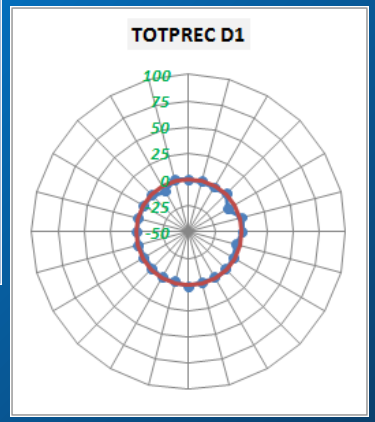
In reference to the *sensitivity* concept, Metiterranean demonstrates befiting *similarities* with internal domains related to *Switzerland*, Italy, Greece and Israel (at least …).

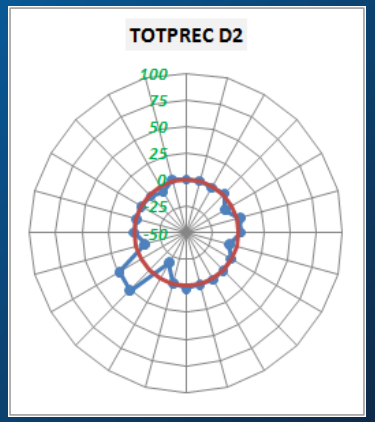
http://www.cosmo-model.org/content/consortium/generalMeetings/general2017/parallel/COSMO-GM2017_parallel_Euripides.pdf

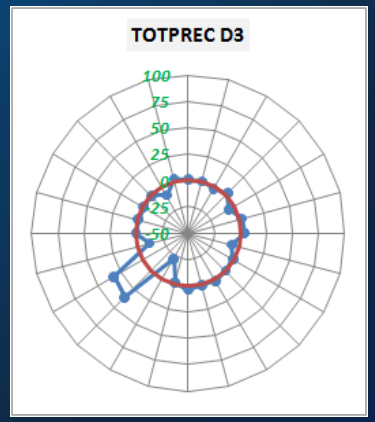
http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport42.pdf

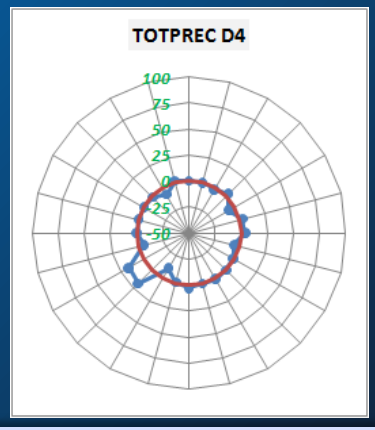


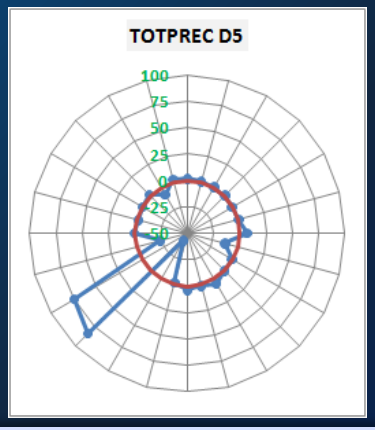


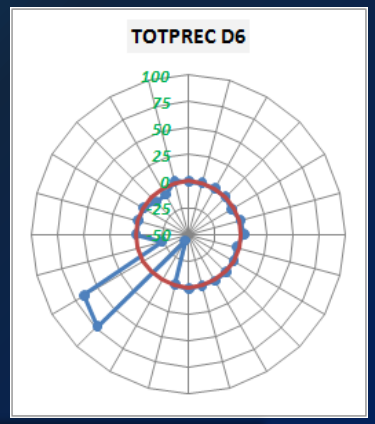


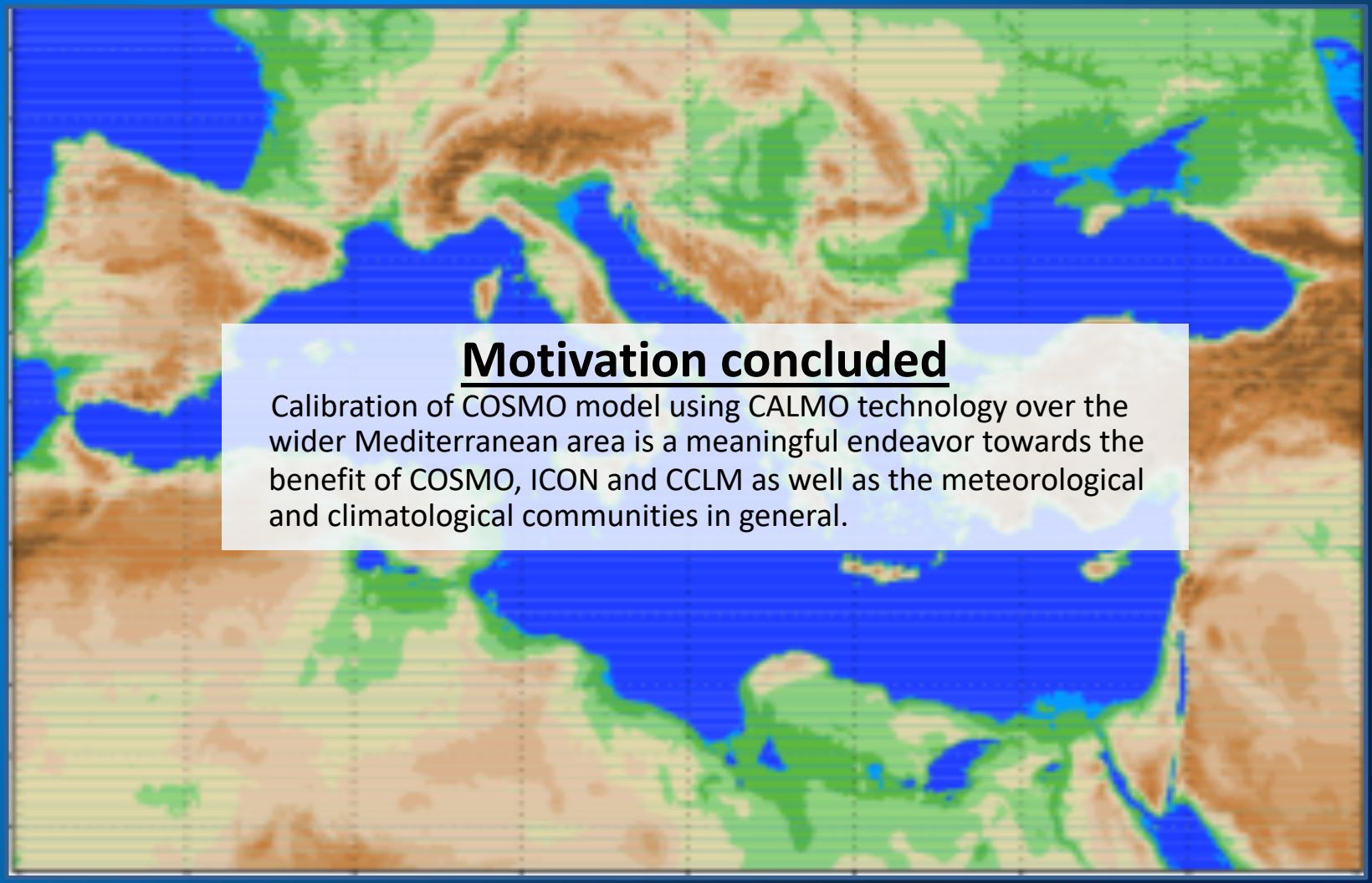












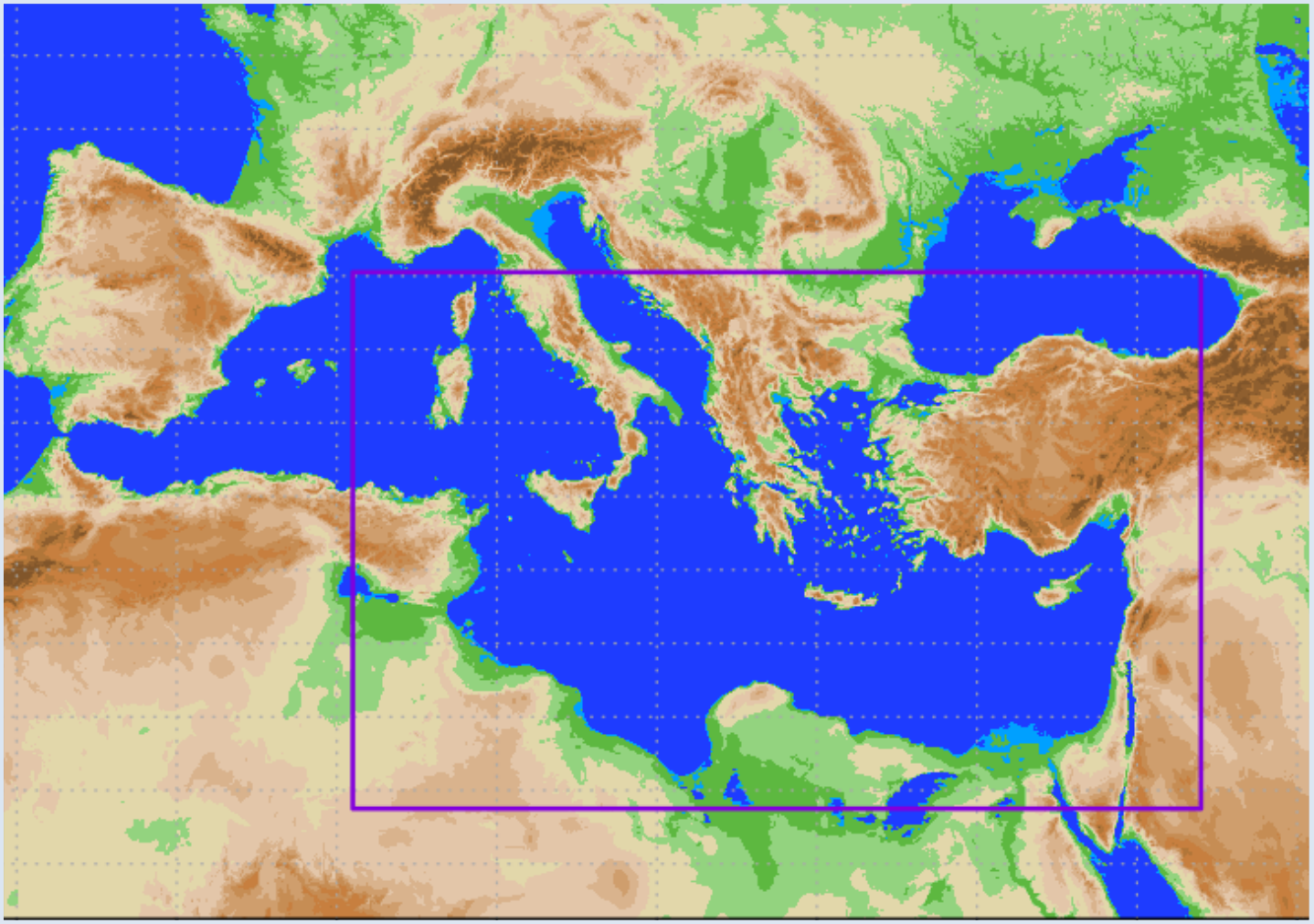
Motivation concluded

Calibration of COSMO model using CALMO technology over the wider Mediterranean area is a meaningful endeavor towards the benefit of COSMO, ICON and CCLM as well as the meteorological and climatological communities in general.

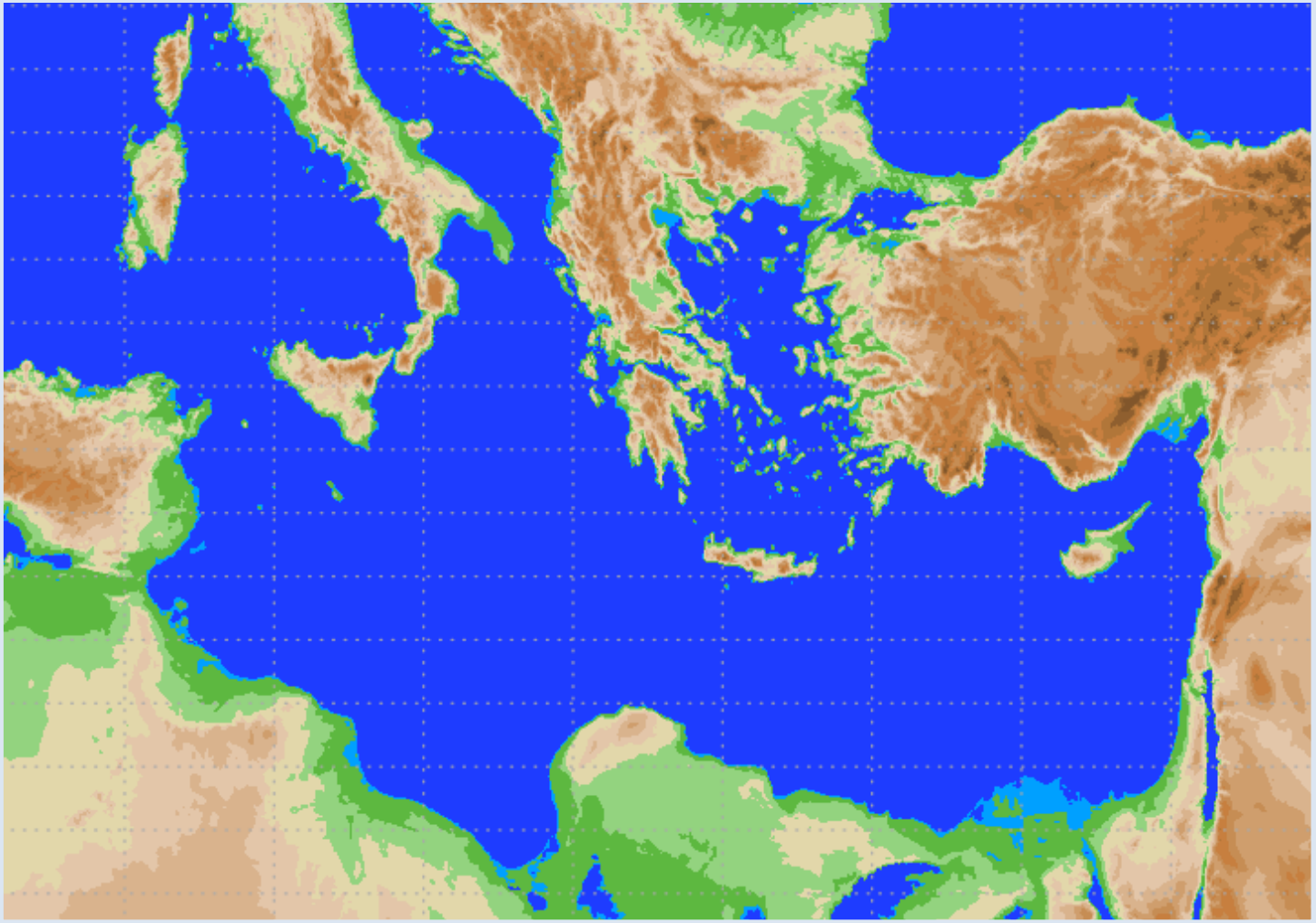
Implementation of Tests

- Domain choice
- Model version and set up
- Parameter list
- Case choice
- Computational resources
  - Computer system
  - Cost of model runs
  - Cost of output storage
- Comments on “cross term” selection.

❑ Domain choice *considerations*



- Domain choice: Wider Eastern Mediterranean Area



Model version and set up

- cosmo_190418_5.06_1
- int2lm_190524_2.06
- Horizontal grid size: 0.03^0 (~3 km)
- 890x487 grid points
- 53 vertical levels (Tropopause at 33 km)
- Integration time-step: 15 secs.
- Time interval of radiation scheme call : 15 mins
- Integration period: 42 hs.
- Boundary conditions : 6hr IFS Analysis.

❑ Parameter list

PARAMETER	INTERPRETATION	RANGE	TEST VALUES (default)
rat_sea	ratio of laminar scaling factors for heat over sea	1-100	1, 10, 50
rlam_heat	scaling factor of the laminar boundary layer for heat	0.1 – 10.0	0.1, 1.0, 2.0
tkhmin tkmmin	minimal value of diffusion coefficient for heat and momentum (kept equal)	0.0-2.0	0.1, 0.40, 2.0
tur_len	asymptotic maximal turbulent length scale (m)	10 – 10000	100, 150, 1000
c_soil	surface area index of evaporative soil surfaces (dependent on surface area density of the roughness elements over land , c_lnd)	0-c_lnd(2.0)	0, 1, 2

cosmo_userguide_5.06.pdf

Also in the namelist group /TUNING/ there are some variables that are chosen differently in the ICON setup. At least compared to the settings that were used at DWD for COSMO-DE or for the former COSMO-EU. Of course the choice of these variables depend on special configurations and domains. The following table lists the variables that are now chosen at DWD for COSMO-D2 ("OLD") and for ICON ("NEW").

/TUNING/	OLD	NEW	Explanation	Default
tkhmin	0.4	0.75	Minimal diffusion coefficients [in m^2/s] for vertical scalar (heat) transport.	1
tkmmin	0.4	0.75	Minimal diffusion coefficients [in m^2/s] for vertical momentum transport.	1
rat_sea	20.0	7.0	Ratio of laminar scaling factors for heat over sea and land.	10.0
pat_len	500.0	750.0	Effective length scale of subscale surface patterns over land [in m].	100.0
tur_len	150.0	500.0	Asymptotic maximal turbulent distance [in m].	500.0
a_hshr	1.0	2.0	Length scale factor for separate horizontal shear production.	1.0
c_soil	1.0	1.75	Surface area density of the (evaporative) soil surface.	1.0

- Case choice

60 cases were chosen from year 2019, 5cases/month (case_d2019**mmdd**_00/), i.e.:

case_d20190102_00/ case_d20190109_00/ case_d20190114_00/ case_d20190119_00/ case_d20190123_00/
case_d20190205_00/ case_d20190207_00/ case_d20190212_00/ case_d20190214_00/ case_d20190222_00/
case_d20190302_00/ case_d20190312_00/ case_d20190314_00/ case_d20190316_00/ case_d20190327_00/
case_d20190405_00/ case_d20190411_00/ case_d20190414_00/ case_d20190417_00/ case_d20190420_00/
case_d20190504_00/ case_d20190507_00/ case_d20190513_00/ case_d20190523_00/ case_d20190527_00/
case_d20190601_00/ case_d20190605_00/ case_d20190610_00/ case_d20190614_00/ case_d20190617_00/
case_d20190705_00/ case_d20190710_00/ case_d20190716_00/ case_d20190718_00/ case_d20190722_00/
case_d20190804_00/ case_d20190815_00/ case_d20190816_00/ case_d20190817_00/ case_d20190824_00/
case_d20190901_00/ case_d20190912_00/ case_d20190914_00/ case_d20190920_00/ case_d20190923_00/
case_d20191002_00/ case_d20191007_00/ case_d20191017_00/ case_d20191024_00/ case_d20191030_00/
case_d20191103_00/ case_d20191109_00/ case_d20191112_00/ case_d20191115_00/ case_d20191124_00/
case_d20191201_00/ case_d20191203_00/ case_d20191210_00/ case_d20191213_00/ case_d20191224_00/

The main criterion for the case choice is the development of extensive precipitation

- Computational resources
  - Computer system

    ECMWF Cray HPCF XC40 cluster #63 (TOP 500, June 2020)

https://www.ecmwf.int/en/computing/our-facilities/supercomputer

Computational resources

- Computational cost of model runs:

  In kind provision of billing units by HNMS at ECMWF supercomputing system to run the model

  (~ 50 million billing units).

- Computational cost of a single run:

  ~ 18000 b.u$_s$., ~3000 secs (2880 cpus).

- Current use of b.u$_s$.: ~ 25 milion

- Computational resources
  - Volume of output storage:
    - ~ 11.5 GB / run (*.tar.bz2).
    - ~ 15 TB Total at ECFS.

SENSITIVITY TESTS BLUEPRINT

5 parameters are considerd.

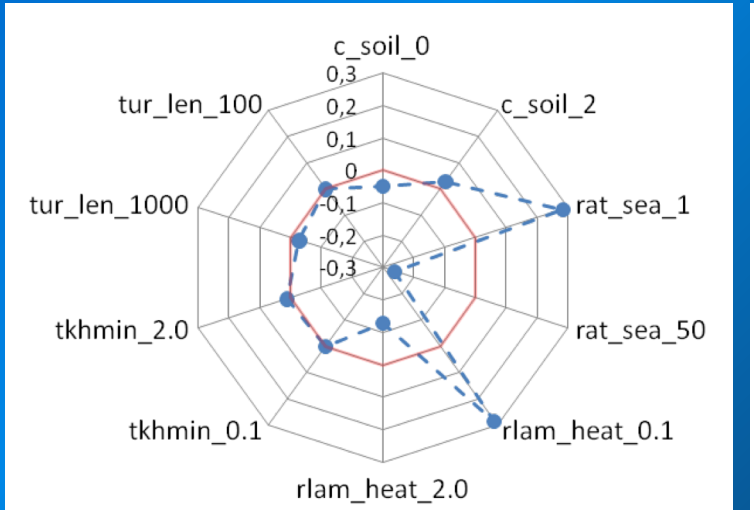
The evaluation period consists of 60 dates from year 2019, i.e.:
12 months x 5 dates/month.

21 runs/date = 1 default + 5 min + 5 max parameter values +
10 combinations of different parameter pairs

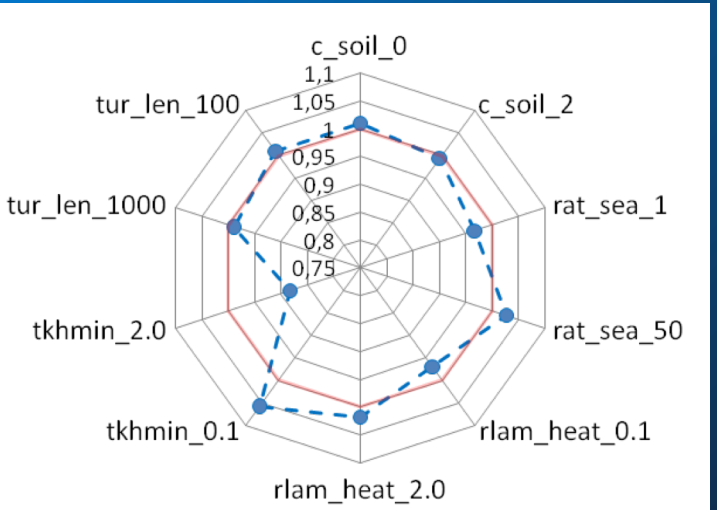
1260 runs based on cosmo_190418_5.06_1

- Horizontal grid size: 0.03^0 (~3km).
- 890x487 grid points (wider Eastern Mediterranean Area), 53 levels.
- Integration time-step: 15 secs.
- Integration period: 42 hs.
- Boundary conditions : 6hr IFS Analysis.
- Computational Cost: ~ 25 milion b.u. on Cray XC40 of ECMWF (gratis HNMS).
- Storage Volume: ~ 15TB stored permanently at ECFS (bz2 compression).

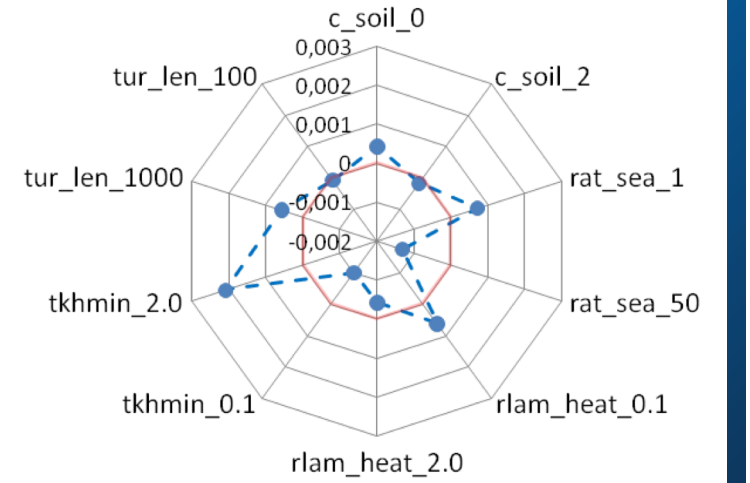
- Comments on “cross term” selection based on time-areal average of TOT_PREC, T2M_MIN, T2M_MAX.



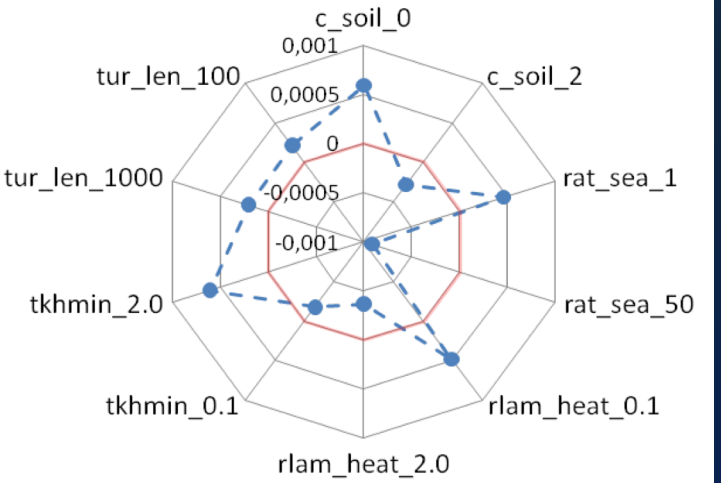
(<TOT_PREC>TEST-<TOT_PREC>DEFAULT) / <TOT_PREC>DEFAULT



<TMAX_2M-TMIN_2M>TEST / <TMAX_2M-TMIN_2M>DEFAULT



(<TMIN_2M>TEST-<TMIN_2M>DEFAULT) / <TMIN_2M>DEFAULT



(<TMAX_2M>TEST-<TMAX_2M>DEFAULT) / <TMAX_2M>DEFAULT

	c_soil_0	c_soil_2	rat_sea_1	rat_sea_50	rlam_heat_0.1	rlam_heat_2.0	tkhmin_0.1	tkhmin_2.0	tur_len_1000	tur_len_100
c_soil_0										
c_soil_2										
rat_sea_1		4B TMAX								
rat_sea_50	4A TMAX									
rlam_heat_0.1		5B TMAX		1A TOT_PREC						
rlam_heat_2.0	5A TMAX		1B TOT_PREC							
tkhmin_0.1	7B TMAX		2B T_RANGE		3B T_RANGE					
tkhmin_2.0		7A TMAX		2A T_RANGE		3A T_RANGE				
tur_len_1000		8A TMIN		6A TMIN		9A TMIN		10A TMIN		
tur_len_100	8B TMIN		6B TMAX		9B TMIN		10B TMIN			

21 runs per case acording to min/max and cross terms.

dyyyymmdd_00_**default**.tar.bz2
dyyyymmdd_00_**rat_sea_1**.tar.bz2
dyyyymmdd_00_**rat_sea_50**.tar.bz2
dyyyymmdd_00_**c_soil_0.**tar.bz2
dyyyymmdd_00_**c_soil_2**.tar.bz2
dyyyymmdd_00_**rlam_heat_0.1**.tar.bz2
dyyyymmdd_00_**rlam_heat_2.0**.tar.bz2
dyyyymmdd_00_t**khmin_0.1**.tar.bz2
dyyyymmdd_00_**tkhmin_2.0**.tar.bz2
dyyyymmdd_00_**tur_len_100**.tar.bz2
dyyyymmdd_00_**tur_len_1000**.tar.bz2

dyyyymmdd_00_**c_soil_2_tkhmin_2.0**.tar.bz2
dyyyymmdd_00_**c_soil_2_tur_len_1000**.tar.bz2
dyyyymmdd_00_**rat_sea_50_c_soil_0**.tar.bz2
dyyyymmdd_00_**rat_sea_50_rlam_heat_0.1**.tar.bz2
dyyyymmdd_00_**rat_sea_50_tkhmin_2.0**.tar.bz2
dyyyymmdd_00_**rat_sea_50_tur_len_1000**.tar.bz2
dyyyymmdd_00_**rlam_heat_2.0_c_soil_0.tar**.bz2
dyyyymmdd_00_**rlam_heat_2.0_tkhmin_2.0.tar**.bz2
dyyyymmdd_00_**rlam_heat_2.0_tur_len_1000.tar**.bz2
dyyyymmdd_00_**tkhmin_2.0_tur_len_1000**.tar.bz2

Concluding Remarks

- A fair model output is available at ECMWF for calibration according to CALMO methodology.
- Further runs are possible according to possible recommendation s upon the progress of calibration
- Disk Space is an issue but data thinning is a straightforward process upon implementation of fieldextra.
- Porting the calibration process at ECMWF is expected to be a very important endeavor for COSMO.